UNION UNIVERSITY

COURSE SYLLABUS

I. BASIC INFORMATION

Department of Chemistry
CHE 435
Advanced Organic Chemistry
Four (4) semester hours credit

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II. SCOPE OF COURSE

This course is a continuation of the study of organic chemistry begun in CHE 314 - 315. Students enrolling for CHE 435 must have successfully completed CHE 315 or its equivalent. The relationship between chemical behavior (reactivity), molecular structure, and chemical environment (solvent/phase effects) will be explored in greater depth than in the introductory organic chemistry courses. Initially, the course will consist of in-depth review of functional group organic chemistry. The first part of the course will include a review/practical treatment of spectroscopy as it applies to organic structural analysis. Emphasis will be placed on the interpretation of infrared, ultraviolet/visible, and nuclear magnetic resonance spectra. The classes of compounds that will be studied include amines, alcohols, carbonyl compounds, carboxylic acids and their derivatives, aryl halides, polynuclear aromatics, and heterocyclic compounds. The topics will be discussed from a physical organic perspective. For example, the conservation of orbital symmetry with its application to thermal and photolytic ring opening/closure reactions will be thoroughly discussed. Finally, topics in molecular orbital theory/quantum calculations, molecular-modeling, heterocyclic/natural product synthesis and combinatorial chemistry will be discussed as time permits near the end of the semester.

III. COURSE OBJECTIVES

The general objectives of the course are:

1. To expand dramatically knowledge of functional group chemistry;
2. To hone the technique of critical and logical thinking in order to understand the behavior of organic compounds;
3. To become more proficient in the skills of interpreting spectral information;
4. To understand the role of subtle structural characteristics in organic reaction mechanisms; and
5. To continue to gain insight into the relevance of organic chemistry to societal problems such as genetic manipulation, environmental pollution, and the continuing global energy crises.

IV. TEXTBOOKS AND MATERIALS

The required textbooks for the course are ***Organic Chemistry*** (7th edition) by Francis A. Carey (or an equivalent introductory organic chemistry textbook) and ***Advanced Organic Chemistry:*** *Reactions and Mechanisms* (2nd edition) by Bernard Miller. Students may find the ***Study Guide and Solutions Manual*** by Francis A. Carey and Robert C. Atkins a useful supplement to the first textbook. However, purchase of the ***Study Guide*** is optional as is the purchase of the Framework Molecular Model Kit (Prentice-Hall). The Online Learning Center and Learning with Modeling CD-ROM bundled with the Carey textbook will also permit the three-dimensional visualization of organic molecules and exercises in molecular modeling. ChemDraw v.11 may be used to publish organic structures in reports and papers and is available to all students with an email address @uu.edu. The installation disk for Windows or Mac OSX can be checked out in Dr. Randy Johnston's office. Exercises in molecular-modeling may also be performed using the Chem3D software. Students have found the latter study aids particularly useful while learning to visualize the structures of organic molecules. Use of the model kit is permitted on all tests and quizzes (Exceptions: ACS Standardized Examinations).

V. ASSIGNED READING AND RESEARCH

The required reading for this course includes chapters 13-24 of the textbook. Additional reading will be necessary in order to achieve full comprehension of the topics covered in the course. Helpful sources may be found in the bibliography attached to this syllabus. There is also a helpful reading list for each chapter in the textbook.

VI. SPECIAL PROJECTS/ACTIVITIES

A term paper of 10 - 15 pages (excluding endnotes and bibliography) in length will be written during the first half of the term. The paper may be created with Microsoft Word and should be produced in 12 point Times or Times New Roman font, doubled-spaced. A hardcopy and an electronic copy of the paper will be due **Tuesday, December 1**. The electronic copy may be submitted as a pdf attachment to an email. The topic of the paper will be assigned by the instructor in consultation with each student and will be a current topic in organic chemical research. The form and content of the paper will contribute equally to the grade for the report. The style manual for the paper will be ***The ACS Style Guide*** (3rd edition), the form used in the journals of the American Chemical Society. The style guide is available in the university library and in the university bookstore. During the last two weeks of the semester, each student will make a 10-15 minute PowerPoint presentation on the topic of his/her term paper.

A record of all experimental procedures, observations, and conclusions should be kept in a laboratory journal. Formal wordprocessed reports prepared (using applications described in the previous paragraph of this section) will be required for two multi-step experiments and should contain the following information:

1. Statement of objective(s)
2. Description of procedure (in 3rd person, past tense) including important reactions and a table of physical constants
3. Observations, data and calculations (differentiate between data and calculated results)
4. Interpretation of results and conclusions (this is the most time-consuming portion of the experiment and report)

The two laboratory reports that will be formally submitted are:

Experiment	Due	
Synthesis of Diphenylacetylene	1009	F
The Pinacolone Rearrangement	1113	F

VII. METHOD OF INSTRUCTION

The course is taught by the lecture/demonstration method. The instructor relies heavily on student participation during the course of each lecture. This requires that students thoroughly review classnotes between each class meeting and read the portions of the textbook pertinent to the topics scheduled for each session of the class. It should be remembered that courses at the advanced undergraduate level require greater discipline and depth of commitment than introductory courses. To reinforce several concepts, computer-assisted instructional programs will be available for use on an individual basis.

The predominant teaching style in the laboratory will be coaching. Students will be guided through a number of experiments which will be performed individually, in pairs, or small teams. Students are expected to read the description of each experiment in the laboratory handout before the laboratory period in which the experiment is scheduled to be performed. Objectives, experimental procedures, reactions, and important physical constants for all chemical elements and compounds that will be encountered in a given experiment should be recorded in the laboratory notebook(journal) before the laboratory period begins. Each student is expected to keep an account in the laboratory journal of each experiment as it is performed. The journal will be reviewed by the instructor one or two times during the semester. The journal will also be the main source of information for two formal laboratory reports which will be submitted during the semester (see Section VI).

VIII. METHOD OF EVALUATION

Each student's grade in the course shall be determined by his/her performance on major quizzes, short quizzes or problem sets (usually each Thursday), a term paper and oral presentation, and a comprehensive final examination. Each student may accumulate a total of 1000 points. The short quizzes taken together carry the same weight as one major quiz. The major quiz or short quiz total which makes the least contribution to the final point total will be excluded in the final computation. No makeup quizzes shall be given unless arrangements are made in advance of foreseen absences or immediately following unforeseen absences due to sickness or family trauma.

Each activity shall be weighted as follows:

Activity	Points
Major Quizzes (2)	400
Short Quizzes (~7)	
Term Paper	150
Laboratory Reports/Journal	200
Final Examination	250
TOTAL	1000

The major quizzes and term paper due date are as follows:

Major Quiz #1	Tuesday, October 13, 2009
Term Paper Due Date	Tuesday, December 1, 2009
Major Quiz #2	Tuesday, November 23, 2009

The final course grade will be assigned utilizing the following scale.

Total Points	Course Grade
1000-900	A
800-899	B
700-799	C
600-699	D
Below 600	F

These evaluation procedures are subject to ratification by the class at its first meeting.

IX. ATTENDANCE POLICY

It should be recognized that courses of study that are most worthwhile are those which evoke much study and preparation by the student and the instructor. It is the instructor's opinion (and personal goal) that each class meeting will be worthy of the student's attendance and participation. Although no point deduction will occur for unexcused absences, excessive absences will render impossible the achievement of the course objectives. Students are responsible for all material covered in class and should obtain classnotes from fellow class members when absences do occur.

X. OUTLINE OF COURSE

I. Arenes
  A. Reactions
    1. electrophilic aromatic substitution
      a. representative reactions
    2. orientation of substitution
    3. rate of substitution
    4. mechanism of electrophilic addition

II. Spectroscopy
  A. Mass spectrometry
  B. Infrared and ultraviolet
  C. Nuclear magnetic resonance
    1. chemical shift
    2. splitting and coupling constants
    3. carbon-13
  D. Electron spin resonance

III. Organometallic Compounds
    A. Nature of the carbon-metal bond
    B. Nomenclature
    C. Organolithium and organomagnesium compounds
        1. preparation
        2. synthetic applications
    D. Other useful organometallics - copper, zinc, cadmium, and mercury

IV. Alcohols, Diols, and Thiols
    A. Structure and nomenclature
    B. Preparation
        1. oxymercuration-demercuration
        2. oxidative hydroboration
        3. reductive methods
        4. Grignard synthesis
    C. Reactions
        1. cleavage of the C-OH bond
        2. cleavage of the CO-H bond
        3. oxidation
        4. iodoform reaction
        5. Williamson synthesis

V. Ethers, Epoxides and Sulfides
    A. Structure and nomenclature
    B. Preparation
        1. intermolecular "dehydration" of alcohols
        2. Williamson ether synthesis
        3. solvomercuration-demercuration of alkenes
    C. Reactions of ethers
    D. Epoxide preparation
    E. Reactions of epoxides
    F. Preparation of sulfides
    G. Reactions of sulfides
        1. oxidation
        2. alkylation

VI. Aldehydes and Ketones
    A. Structure and properties
    B. Synthesis
    C. Reactions at the carbonyl group
        1. nucleophilic addition
        2. acetal formation
        3. selected name reactions

VII. Enols and Enolates
    A. Reactions at the α-carbon in carbonyl compounds
    B. Enolization
    C. Aldol condensations
    D. Conjugated aldehydes and ketones
        1. β-unsaturated carbonyl compounds

VIII. Carboxylic Acids
    A. Structure and nomenclature
        1. physical properties
        2. chemical properties
            a. acidity

VIII. Carboxylic Acids
    B. Synthesis
    C. Reactions
        1. mechanism of acid-catalyzed esterification
        2. lactone formation
        3. decarboxylation

IX. Derivatives of Carboxylic Acids
    A. Structure and nomenclature
    B. Preparation
        1. acid chlorides
        2. acid anhydrides
    C. Reactions
        1. ester hydrolysis
            a. acid-catalyzed
            b. base-catalyzed
        2. amides
        3. lactams and imides
        4. Hofmann rearrangement

X. Ester Enolates
    A. Base-catalyzed condensation reactions
        1. Claisen condensation
        2. Dieckmann condensation
        3. Acetoacetic ester synthesis
        4. Malonic ester synthesis
            a. barbiturates
        5. Michael reaction
        6. Knoevenagel condensation
        7. Reformatsky reaction

XI. Amines
    A. Structure and properties
        1. basicity
    B. Preparation
        1. reduction and reductive amination
        2. Hofmann degradation
        3. Gabriel synthesis
    C. Reactions
        1. alkylation and amide formation
        2. ring substitution in aromatic amines
        3. nitrosation and elimination from quaternary compounds
        4. reactions involving diazonium salts
            a. sulfa drugs

XII. Aryl Halides
   A. Structure and properties
   B. Reactions
      1. nucleophilic aromatic substitution

XIII. Phenols
   A. Nomenclature
   B. Structure and physical properties
      1. acidity
   C. Reactions
      1. esterification
      2. carboxylation
         a. aspirin
      3. ether formation
         a. dioxin
      4. quinone formation

XIV. Molecular Orbital Theory
   A. LCAO method
   B. Orbital symmetry and chemical reactions
   C. Electrocyclic reactions
   D. Cycloaddition reactions
   E. Sigmatropic reactions

XV. Heterocyclic Compounds
   A. Five-membered rings
      1. pyrrole, furan and thiophene
   B. Six-membered rings
      1. pyridine
   C. Skraup synthesis
   D. Bischler-Napieralski synthesis

X. LABORATORY SCHEDULE

Date		Experiment
828	F	Laboratory Operating Procedures/Check In/Safety Orientation
904	F	The Thiamine-catalyzed Benzoin Condensation
911	F	Synthesis of *E* -Stilbene
918	F	Synthesis of Diphenylacetylene
925	F	Complete multi-step synthesis
1002	F	Synthesis of 7,7-Dichlorobicyclo[4.1.0]heptane
1009	F	Photochemistry: The Photosynthesis of Benzopinacol
1016	F	Fall Holidays
1023	F	The Pinacolone Rearrangement
1030	F	Complete workup and characterization of rearrangement product
1106	F	Aqueous Organic Chemistry: Synthesis of 1-Phenyl-3-buten-1-ol [1]
1113	F	Photodimerization of Anthracene: A **[$4\pi_s$ + $4\pi_s$]** Photochemical Cycloaddition [2]
1120	F	Complete workup and characterization of cycloaddition product; Begin Clean up/Check out
1125-1129		Thanksgiving Holidays
1204	F	Complete Clean up/Check out; Laboratory Final Examination

[1] *Journal of Chemical Education*, **1998**, 75, 85.

[2] *Journal of Chemical Education*, **1998**, 75, 81

XI. BIBLIOGRAPHY

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